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CONTROL TECHNOLOGY FOR IN-SITU OIL SHALE RETORTS. FEBRUARY MONTHLY PROGRESS REPORT

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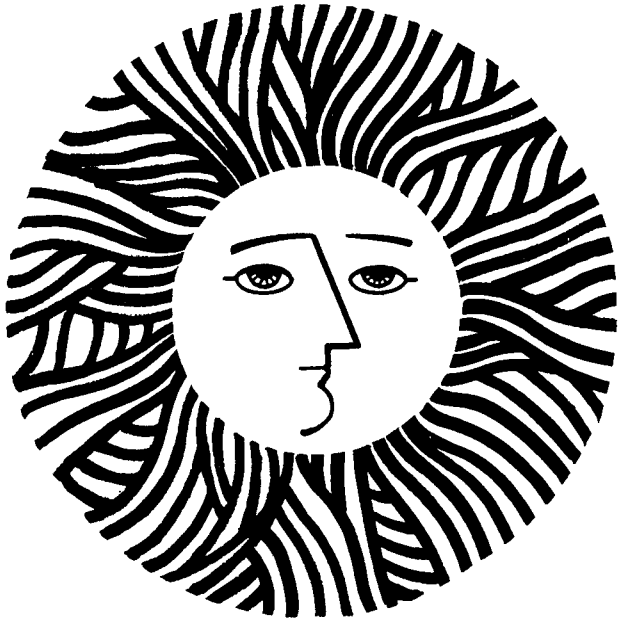

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LAWRENCE BERKELEY LABORATORY
Room: 128 Bldg.: 70 Ext.: 5931

March 11, 1980

TO: Charles Grua, Art Hartstein, and Paul Weiber

FROM: Peter Persoff, Joe Ratigan, Mohsen Mehran, and Phyllis Fox

RE: February Monthly Progress Report
Control Technology for In-Situ Oil Shale Retorts
LBID-177

DOE PEER REVIEW

This program, along with other DOE-sponsored programs directed at retort abandonment, was reviewed during February. Presentations of the work accomplished under the several tasks were made to a panel of experts from DOE and industry. We expect to receive formal review comments later in the year.

TASK 3. BARRIER OPTIONS

Preparation of grout and grouted core samples.

Samples of low-cost grouts and grouted cores have been prepared. Grout recipes are shown in Table 1. Sixty percent or more of the grout solids consists of Lurgi spent shale as received; thirty percent or more is sand, simulating lean raw shale fines. Cement content (portland cement or cement made from Lurgi spent shale) ranges from zero to ten percent. The use of sand or lean raw shale fines permits reasonable flow properties (time of efflux from a standard grout flow cone of 20 ± 2 sec) with water-solid ratios low enough to prevent bleeding of the grout.

Specimens have been made both with coarse aggregate, for triaxial compressive strength tests, and without, for permeability measurement. The coarse aggregate, simulating in-situ spent shale rubble, is material from LETC's retort run S-55 which was crushed and screened to -3/8" +1/4".

Samples were prepared by a modification of ASTM C-31, which is the standard method for preparing concrete samples for

Table 1. Candidate grouts.

	SAMPLES				
	Q-0	Q-1	Q-3	Q-4	Q-5
Lurgi spent shale[a], g	1500	1500	1500	1500	1500
Sand -30 +50 mesh[b], g	750	750	750	750	750
Portland cement, g	0	56.3	0	0	0
Lurgi spent shale cement[c], g	0	0	56.3	112.5	225
Simulated ground water[d], ml	1320	1430	1400	1602	2025
Water-solids ratio	0.587	0.620	0.607	0.678	0.818
Flow cone time, sec.	20.5	19.9	21.4	20.3	22.5
Grout density, g/ml	1.65	1.65	1.68	1.57	1.56

[a] material collected in electrostatic precipitator from Lurgi run 9 (1976).

[b] simulating lean raw shale fines.

[c] $CaCO_3$-Lurgi spent shale ratio 0.9, calcined 1 hr at 1000°C, 5% gypsum added.

[d] 0.61 g $NaHCO_3$ and 0.88 g Na_2SO_4 per liter to simulate native groundwater.

testing. Grout and coarse aggregate were mixed in a bowl, and packed into waxed cardboard cylinder molds, 2 inches in diameter by 4 inches long. Molds were filled in three layers, each layer being rodded to eliminate trapped air. This method of sample preparation was chosen to ensure reproducibility, and does not necessarily simulate rubble into which grout has flowed. The ability of grout to flow into rubble will be tested separately.

Retort structural model calculations.

Previous investigations have been concerned with the determination of the stiffness and strength requirements of a structural grouted retort. These studies have assumed that the retort was completely grouted (i.e., no void space). To evaluate the significance of less than 100 percent grouting, the finite element program used for subsidence prediction has been modified to allow incorporation of an arbitrary initial void ratio in the grouted retorts. Calculations will be performed during March to evaluate the strength and stiffness requirements for retorts with a range of initial void ratios resulting from incomplete grouting.

A report of the results to date is presently in preparation.

TASK 5. LEACHING OPTIONS

Work continued on the development of the mathematical model of the leaching and transport of organic carbon in abandoned in-situ retorts. Efforts were concentrated in two areas: diffusion mechanisms within the solid phase of the shale particles and natural convective flow patterns in the shale bed.

Diffusion of the solute within the pores of the solid phase was investigated as a possible rate-limiting step in the leaching and transport of organic carbon. A promising method of measuring the diffusion rate within the particle was developed. The rate of change of concentration of a solute in a stirred solution containing a known volume of shale can be related mathematically to the diffusion coefficient of the solute within the boundaries

of the shale particle. A small-scale batch study was started to investigate the feasibility of the method.

Natural convective flow in the shale bed is caused by density gradients in the leachate created by variation in the dissolved salt content. The denser liquid containing more dissolved salts tends to fall and the less dense fluid rises. A simple mathematical model was formulated for natural convective flow past individual shale particles. Maximum velocities of leachate determined from this model were found to be on the same order of magnitude as the average pore velocity of the bulk flow pumped through the column, indicating that natural convection due to density differences in the leachate is a significant factor. The natural convective flow model is being extended to describe flow past multiple particles.

Small-scale column leaching studies are continuing. Two additional studies in the 11.5 cm diameter columns were started involving pore velocities of about 1.5 and 3.0 meters per day.

TASK 6. HYDROLOGIC OPTIONS

Development of dewatering model.

The mesh which was previously used to test the Theis solution was modified for application to tract C-b in the Piceance Creek Basin. The mesh extends radially to 15 km.

Calculations were initiated to determine the effect of dewatering on local stream flow. These calculations used a circular area equivalent to one year of retort development, and it was assumed that dewatering could be achieved by internal drainage of the retorted areas (Tipton and Kalmbach, 1977). The water table was assumed to be 612 meters above the bottom of the lower aquifer. Two cases of pressure-dependent hydraulic conductivity relationships were used for the unsaturated flow. In one case, the hydraulic conductivity was 25 times greater than the other case.

The location of zero pressure head (water level) for two assumed permeabilities for Occidental's proposed development plans for tract C-b are shown in Figure 1. This figure indicates that local streams and springs may be dried up early in the development of tract C-b. Preliminary results indicate that the Tipton and Kalmbach predictions of dewatering flows are low by more than an order of magnitude. Their calculation methods, which used the Jacob-Lohman equation, did not consider drainage from the column of water above a field of retorts and therefore were low. Our results also indicate that unsatured flow, previously not considered in hydrologic calculations of oil shale development, will be very significant in investigating dewatering and hydrologic impacts. Capillary pore pressure, which increases as the percent saturation decreases, will impede the dewatering or drainage of a site and reduce flow velocities when groundwaters reinvade a retorted area.

REFERENCES

Tipton and Kalmbach, Inc., Engineers, "C-b Tract: Hydrology, Mine Dewatering, and Water Use and Augumentation", Denver, CO, 1977.

--- $K(h)_1$

—— $K(h)_2$

note: $K(h)_2 = 25K(h)_1$; $h>10$

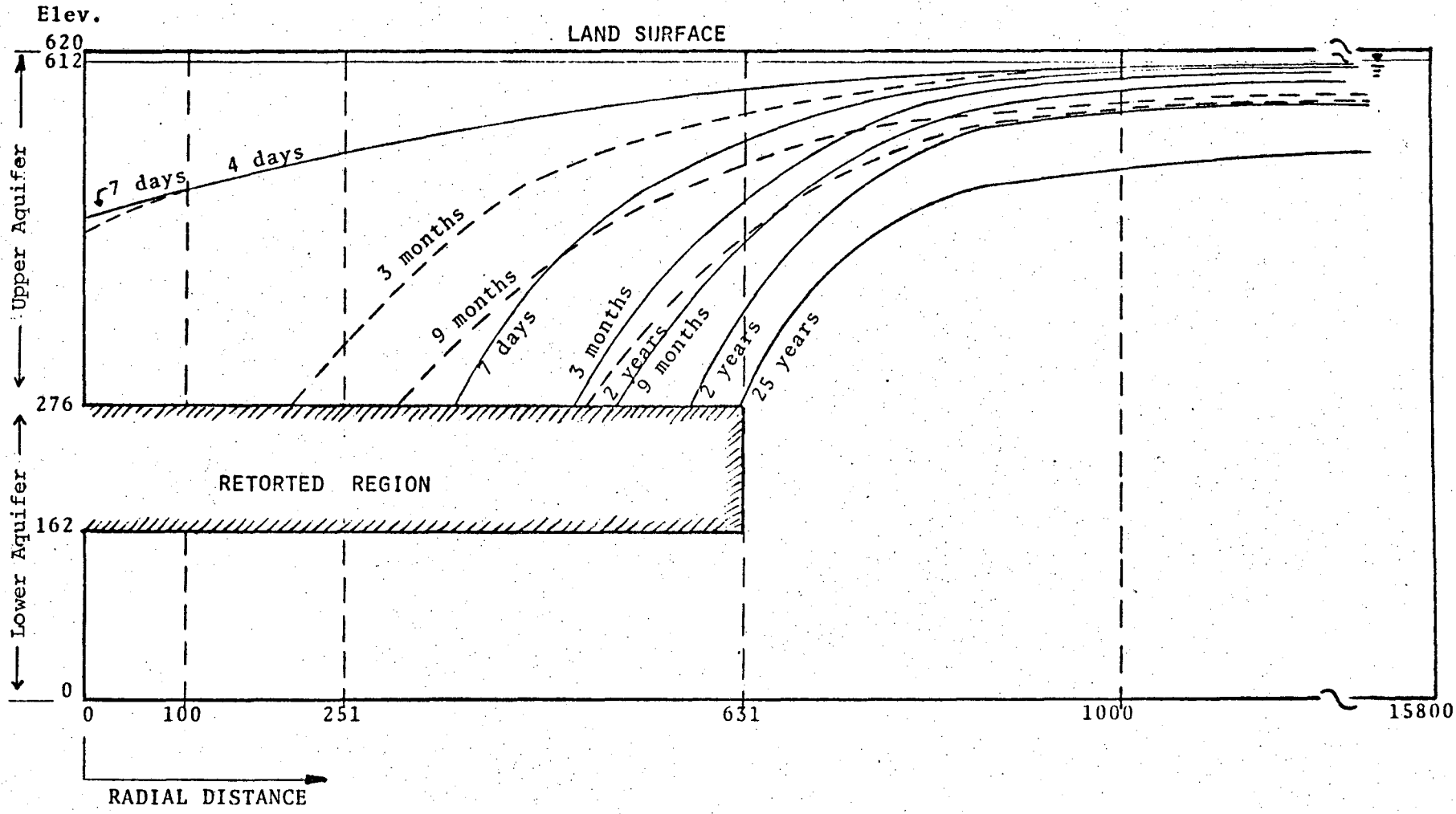

Figure 1. Location of water-level contours for proposed Occidental development at tract C-b.

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